A SURVEY OF FISH CONTAMINATION IN SMALL WADEABLE STREAMS IN THE MID-ATLANTIC REGION

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ABSTRACT

Fish tissue samples were collected from wadeable streams in the Mid-Atlantic Region of the United States (1993-1994). Whole fish tissue samples were prepared from prioritized lists of small and large target species. The two types of samples were analyzed for 56 contaminants, including metals and pesticides, of which 22 had median values that were above the detection limits for at least one category of fish. Data analyses were conducted in order to determine the exposure to contaminants, magnitude of exposure, and locations of sites which exceeded toxicological benchmark values. All sites from which samples were taken showed exposure to at least one contaminant. In order to determine the magnitude of this exposure, no observed adverse effects level (NOAEL) benchmark values for 16 of the analytes were used. The NOAEL benchmark values were compared to the concentration of contaminants found in small target species tissue sampled at each site. Maps were generated which showed the locations of the sites that exceeded the NOAEL benchmark values. Seventy sites (100%) exceeded at least one NOAEL benchmark value and 22 sites (31.43%) exceeded four or more NOAEL benchmark values. The number of sites exceeding multiple NOAEL benchmark values suggests a comprehensive study of fish tissue contaminants is warranted for the region.

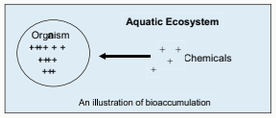
INTRODUCTION

OBJECTIVES

- Determine if fish were exposed to contaminants,
- Determine the magnitude of the exposure, and
- Determine where the exposure exceeded toxicological benchmark values.

BIOACCUMULATION

The analysis of fish tissue samples measures the bioaccumulation of toxic chemicals. Bioaccumulation occurs when organisms incorporate and retain chemicals from the surrounding environment. In aquatic ecosystems, these chemicals are associated with water, sediments, suspended solids and prey organisms. If the incorporation of the chemical outpaces the metabolism or excretion of the chemical, then bioaccumulation occurs. The result is that the concentration of the chemical inside the organism is greater than it is in the environment. Therefore, tissue analysis can reveal the presence of contaminants that may not be detected otherwise because they have such low concentrations in the environment that they cannot be observed through chemical analysis of the water column or sediments.



An illustration of bioaccumulation

WHOLE-FISH ANALYSIS

Fish tissue studies have traditionally focused on the bioaccumulation of contaminants in large game fish because these fish are more likely to pose health risks to humans. Fish tissue studies have also focused on the bioaccumulation of toxic chemicals in the fillets and livers of fish. This study analyzed whole fish of both large and small species and both game and non-game species. While an analysis of the bioaccumulation of toxic chemicals in the fillets of large game fish may give a better indication of the risks to humans from consuming these organisms, whole fish analysis that also includes small non-game fish will give a better indication of the risks to all potential predators, both humans and non-humans.

FIELD METHODS

STUDY AREA

- Mid-Atlantic Region of the United States
- Sampling locations selected using a spatially-constrained, randomized design
- Site selection limited to include only wadeable streams

SAMPLE COLLECTION

- Study was a part of USEPA's Environmental Monitoring and Assessment Program (EMAP)
- Fish collected using pulsed DC backpack electrofishing and supplemental seining
- Reach lengths were 40 times the mean wetted width (min. 150 m, max.500 m)
- Sampling conducted for at least 45 minutes and no more than three hours

- Two categories of target taxa were collected
  - Small Target Species
    - Small adults (< 100 mm)
    - Short-lived
    - Widely distributed
    - Abundant
  - Large Target Species
    - Large adults (> 150mm)
    - Longer-lived (> 3 years)
    - Likely to accumulate contaminants
- Taxa on each list are ranked according to priority for collection
  - Goal was to collect one sample from each list at each sampling site
    - The highest priority taxon available was collected
    - Each sample contained one of the priority taxa
    - Small Target Species samples weighed 50 to 400 g
    - Large Target Species samples were made up of 3 to 5 individuals at least 150 mm long

Priority	Small Target Species
1	Blacknose dace (*Rhinichthys atratulus*)
2	Another Dace species (*Rhinichthys* spp., *Phoxinus* spp., *Clinostomus* spp.)
3	Creek chub (*Semotilus atromaculatus*) or Fallfish (*S. corporalis*)
4	Slimy sculpin (*Cottus cognatus*) or Mottled sculpin.(*C bairdi*)
5	Central stoneroller (*Campostoma anomalum*)
6	A Darter species (*F. Percidae*)
7	A Shiner species (*F. Cyprinidae*)

Priority	Large Target Species
1	White sucker (*Catostomus commersoni*)
2	Northern hogsucker (*Hypentelium nigricans*)
3	A Bass species (*F. Centrarchidae*, *Micropterus* spp.)
4	A Trout species (*F. Salmonidae*)
5	A Sunfish species (*F. Centrarchidae*, *Lepomis* spp.)
6	Common carp (*Cyprinus carpio*)

- Fish were collected from 27 April 1993 to 8 July 1993 and from 18 April 1994 to 24 June 1994
- 102 sites were selected for fish tissue sampling
- Fish tissue samples were collected at 77 of these sites
  - Small Target Species samples collected at 70 sites
  - Large Target Species samples collected at 47 sites

LABORATORY METHODS

SAMPLE PREPARATION

- Samples held at -20°C until analysis
- Whole fish were homogenized

SAMPLE ANALYSIS

Metals determined by one of three techniques
- Cold vapor technique atomic absorption spectrometry (AAS) for Hg
- Graphite furnace AAS for As, Cd, Se, and Pb
- Atomic emission spectrometry for other metals and Cd and Pb in high concentrations

Organic contaminant extraction
- 1 to 10 g of sample dried with sodium sulfate and extracted with methylene chloride
- Extract purified by silica/aluminum column chromatography and high performance liquid chromatography (HPLC)

Quantitative analysis
- Gas chromatography with mass spectrometer detector (MSD) in SIM mode for PAHs
- Electron capture detector (ECD) for pesticides and PCBs

DATA ANALYSES

Exposure
- Detection of contaminants in fish tissue samples was evidence that exposure to contaminants occurred
- Percentages of sites where Small Target and/or Large Target Species showed exposure to contaminants above detection limits were calculated

Magnitude of Exposure
- Benchmark values based on the no observed adverse effects level (NOAEL) for belted kingfisher (Megaceryle alcyon) food consumption (Sample et al. 1996)
- Exceedence of NOAEL benchmark values and degree exceeded were evidence of magnitude of exposure
  - For analyses, 6 DDT metabolites summed for DDT; Endosulfan I and II summed for Endosulfan; alpha-, gamma-, oxy-, cis-nona-, and trans nona-chlordane summed for chlordane
    - Before summing, ½ detection limit used for values below detection limits
  - For contaminants not summed, ½ detection limit used if value below detection limit

Locations of Sites Exceeding Toxicological Benchmark Values
- Locations of sites that yielded Small Target Species samples that exceeded NOAEL values mapped

RESULTS AND DISCUSSION

EXPOSURE

Exposure to most contaminants occurred at moderate to high percentage of sites.

Contaminant	Detection limit (µg/g)	Sites Exceeding Method Detection Limits	
		Small Target Species (N = 70)	Large Target Species (N = 47)
*Aluminum	Not Avail	100.0	100.0
Arsenic	3.7500	5.7	2.1
Cadmium	0.1000	38.6	44.7
Chromium	Not Avail	100.0	100.0
Copper	Not Avail	100.0	100.0
Lead	1.2500	51.4	63.8
Mercury	0.025	84.3	87.2
Nickel	0.150	70.0	78.7
Selenium	3.7500	4.3	2.1
Zinc	Not Avail	100.0	100.0
o,p'-DDD	0.0002	71.4	61.7
o,p'-DDE	0.0002	28.6	14.9
o,p'-DDT	0.0002	62.9	55.3
p,p'-DDD	0.0002	75.7	78.7
p,p'-DDE	0.0002	100.0	100.0
p,p'-DDT	0.0002	10.0	72.3
Aldrin	0.0002	15.7	8.5
Dieldrin	0.0002	100.0	93.6
Endosulfan I	0.0004	7.1	6.4
Endosulfan II	0.0004	18.6	19.1
Endrin	0.0002	11.4	4.3
Heptachlor	0.0002	14.3	4.3
Heptachlor epoxide	0.0002	65.7	57.4
Hexachlorobenzene	0.0002	81.4	63.8
BHC –alpha	0.0002	12.9	10.6
BHC-beta	0.0002	7.1	0.0
BHC-delta	0.0002	2.9	0.0
BHC-gamma	0.0002	25.7	23.4
alpha-Chlordane	0.0002	77.1	68.1
gamma-Chlordane	0.0002	72.9	57.4
cis-Nonachlor	0.0002	88.6	87.2
trans-Nonachlor	0.0002	100.0	100.0
Oxychlordane	0.0002	90.0	91.5
Mirex	0.0002	11.4	10.6
**Total PCBs	NA	NA	NA

*The detected levels of aluminum may have been artificially inflated by the use of aluminum foil in the packaging and storage of samples.
**The concentrations of 21 PCB congeners determined through chemical analysis had detection limits and 0.004 ppb. Maximum Total PCBs were used for data analyses. Although PCBs were detected in all fish samples, there is no applicable detection limit for Total PCBs.

MAGNITUDE OF EXPOSURE

Of the 70 sites where Small Target Species samples were collected, 100% exceeded at least one of the 16 NOAEL values from Sample et al. (1996). The percentage of sites where NOAEL values were not exceeded or were exceeded by factors of 1 or 10 are shown.

Percentage of sites that were less than or exceeded the NOAEL benchmark values and the degree to which they were exceeded. These percentages are based on Small Target Species tissue samples (N=70).

Contaminant	<NOAEL	>1X NOAEL	>10X NOAEL
Arsenic	98.6	1.4	0.0
BHC-gamma	100.0	0.0	0.0
Cadmium	100.0	0.0	0.0
Chromium	91.4	8.6	0.0
Copper	100.0	0.0	0.0
DDT & metabolites	52.9	42.9	4.3
Dieldrin	100.0	0.0	0.0
Endosulfan (I &II)	100.0	0.0	0.0
Endrin	100.0	0.0	0.0
Lead	97.1	2.9	0.0
Mercury	18.6	80.0	1.4
Nickel	100.0	0.0	0.0
Chlordane	100.0	0.0	0.0
Selenium	0.0	100.0	0.0
Zinc	31.4	68.6	0.0
Total PCBs	97.1	2.9	0.0

*The 50% value of the detection limit for selenium is greater than the reported NOAEL value.

Numbers and percentages of sites with varying numbers of contaminants exceeding the NOAEL benchmark values.

Number of contaminants exceeding NOAEL	Number of sites	Percentage of sites
0	0	0.0
1	1	1.4
2	15	21.4
3	32	45.7
4	18	25.7
5	4	5.7

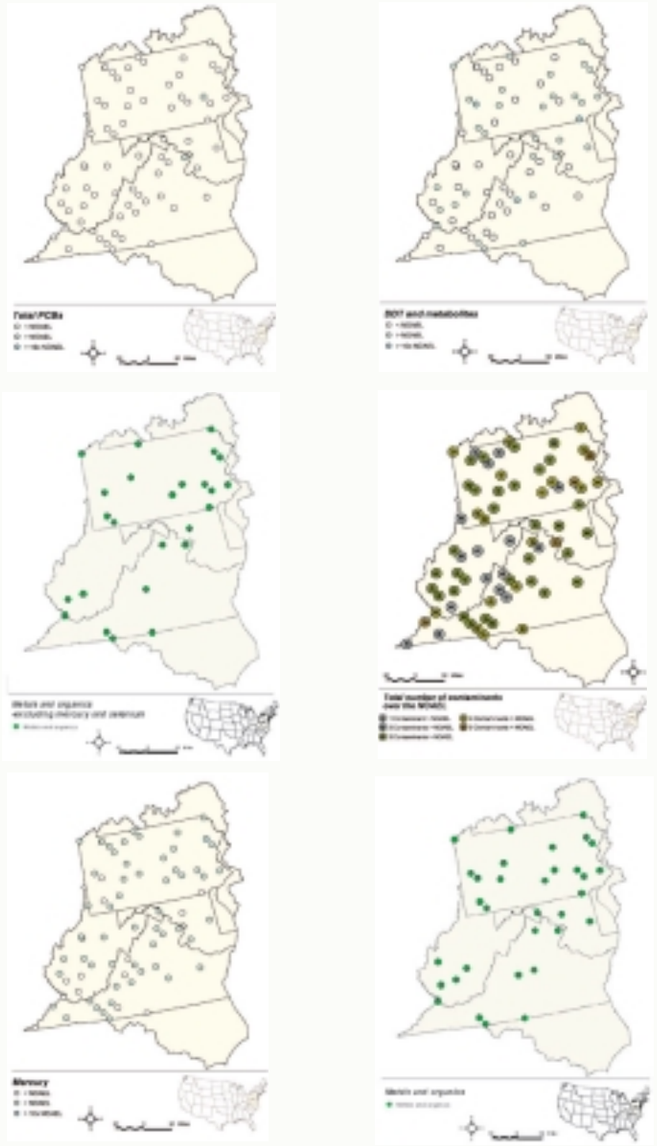
REFERENCE

U.S. Environmental Protection Agency. 2001. A survey of fish contamination in small wadeable streams in the Mid-Atlantic Region. EPA/600/R-00/107. Office of Research and Development, Cincinnati, Ohio.

DISCLAIMER

This poster has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for presentation. Approval does not signify that the contents necessarily reflect the views or policies of the Agency nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Locations of Sites Exceeding Toxicological Benchmark Values



CONCLUSIONS

- Small fish are useful indicators of exposure to contaminants, especially contaminants that are persistent and bioaccumulate
- A number of contaminants were measured above detection limits at more than half of the sites that were sampled
  - Among these were Hg, Zn, DDT metabolites, PCBs, dieldrin and chlordane
  - Some of these may be irreversibly accumulating in the ecosystem or may have very slow rates of decomposition
- Some widely distributed contaminants exceeded NOAEL benchmark values for the belted kingfisher
  - DDT, Hg and Zn exceeded NOAEL values at more than 40% of sites where small target species were collected
- Widespread occurrences of these contaminants suggests that the influence of non-point sources of pollution (e.g., agriculture and atmospheric deposition) should be investigated
- The number of sites exceeding NOAEL benchmarks for Hg, DDT and PCB values suggests that a comprehensive study of fish tissue contaminants is warranted for the region
- While the NOAEL values are very conservative estimations of the effects of a polluted food source on belted kingfishers, they are useful indicators of excess contamination.

ACKNOWLEDGEMENTS

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